USAGE OF HYDROGEN-SATURATED GETTER FOR SPUTTERING PROTECTION OF CONSTRUCTION ELEMENTS IN VACUUM-PLASMA INSTALLATIONS

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One of the most effective ways to solve the problem of sputtering vacuum-plasma installations construction elements, subjected to intensive bombardment by high-energy particles in vacuum, would be in these elements making of metal hydrides. In this case, the particles collisions with the surface of bombarded metal hydride elements, apparently, will mainly result in knockout of more movable hydrogen atoms from interstitials of metal matrix, rather than the atoms of the latter. The endothermic character of hydrogen desorption combined with the possibility of convective heat removal with desorbed gas makes it possible to cool, in addition, the metal hydride element. The layer of desorbed hydrogen forming near bombarded surface can, in turn, create the protective gas target which provides extra dissipation of the energy of a flow of bombarding particles.

In this work the action of plasma flows on the metal hydride material on the basis of hydrogen-saturated getter alloy Zr–V–Fe + B_2O_3 has been investigated. The powdered metal hydride was compacted with the binder (copper powder) into cylindrical sample.

Studying the temperature mode of the ion-bombarded sample was carried out under conditions of burning the reflective discharge in hydrogen environment. In course of it, the sample was as one of the cathodes in the gas-discharge cell; the second (reference) cathode was made of stainless steel, copper or molybdenum. The temperature of the both cathodes was measured with introduced into them thermocouples.

It is shown that the ion-bombarded metal hydride cathode is heated up to a lesser extent than the reference one which is inert with respect to hydrogen. Such a behavior is caused by endothermic heat effect of metal hydride decomposition, as well as by convective heat removal with desorbed hydrogen. The analysis of the heat balance of the metal hydride cathode shows that up to 70% of heat power evaluated herein is spent to these processes. The metal hydride cathode sputtering was practically absent in course of these experiments. At the same time, it took place for a reference cathode, independently of its material. It was observed as appearance of metallic deposit on the surface of quartz plate near the reference cathode.

In the next series of experiments the sample was bombarded by single impulses of N^+ ions having the energy of 2 keV and the density of $2{\cdot}10^{14}$ cm^{-3} (the "Prosvet" coaxial plasma accelerator was used for this purpose). The specific power flow in the impulse 3–5 μs in duration was up to 10 MW/cm^2. It is comparable, as respect to a heat load, with operation conditions of the most energy-loaded construction materials of a fusion reactor.

According to X-ray powder diffraction data, the sample irradiation causes lines broadening in the difractogram and decrease of their absolute intensities. It testifies that the irradiated side of the sample which, according to SEM data, has been subjected to melting, in conditions of desorbed hydrogen bubbling through the melt (i.e. it was fastly cooled after bombarding impulse), has a fine-crystalline or, likely, partially amorphous structure.

During bombardment, the fractions of intermetallic (λ_2 and η) phases in the sample are low changed. At the same time, the similar parameter decreases more than by 10% for copper, and in 1.5 times for zirconium dihydride. At that, in the irradiated sample there arises the additional phase of the $ZrCu_5$ intermetallide. The probable explanation of this fact is the interaction, during ion bombardment impulse, of zirconium hydride with melt of copper which has more low melting temperature than the other components of the sample. As a result, in a course of melt crystallization $ZrCu_5$ (the most rich in copper intermetallide in Zr – Cu system) is formed.

As a whole, the significant changes in the sample phase composition are not observed, and after bombardment the sample weight loss is of 0.1% (corresponding to 0.5 mg/cm^2 per an impulse). It testifies to low enough sputtering susceptibility by intensive plasma flows for the sample based on hydrided zirconium alloy. Therefore, the proposed method of sputtering protection for construction elements of vacuum-plasma installations is effective one.

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